

Public Health Then and Now

Innovations in Health Care: Antisepsis as a Case Study

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Abstract: An innovation often occurs in several arenas almost simultaneously, after being preceded by a long preparatory period when information and experience are accrued to the point at which opinion is influenced to change. Nevertheless, the introduction of an innovation is usually accompanied by resistance and hostility. This article traces the development of the concept and practice of antisepsis in health care, with emphasis on the contributions of three individuals who were contemporaries practicing in different health care fields, but who apparently were uninfluenced by each others' work. Semmelweis, a Hungarian obstetrician, recognized the importance of person-to-person transmission of infectious agents and effected dramatic reductions in puerperal mortality by requiring

antiseptic handwashing. Lister, a Scottish surgeon, was the first physician to apply the germ theory to clinical practice and developed the techniques of antiseptic surgery and wound care, resulting in dramatic reductions in surgical mortality. Nightingale, a British nurse, initiated sanitary reforms in hospitals, schools, and military camps in England and abroad, incorporating high levels of environmental and personal hygiene. These reforms were also succeeded by dramatic reductions in mortality. In light of historical and current evidence of efficacy and the evidence of continued inadequacies in practice, it seems reasonable to speculate that further reductions in nosocomial infection rates are possible by a more careful application among individual practitioners of the basic principles of antisepsis. (*Am J Public Health* 1989; 79:92-99.)

Introduction

On a personal and on a professional level, the necessity for change is accompanied by discomfort, inertia, and resistance. One change that revolutionized health care in the late nineteenth and early twentieth centuries was the development of antisepsis. It continues to be a cornerstone of clinical practice across disciplines, health care settings, and patient populations. This paper traces the historical development of the concept and practice of antisepsis as an example of how change evolves within the health care environment.

The concepts of hygiene and antisepsis arose from three separate sectors within the health care community at about the same time but apparently independently, in the mid-1800s. The earliest records in the medical literature came from the practice of obstetrics and midwifery and efforts to curtail the devastation of puerperal fever. Although others recognized and described the contagious nature of puerperal (childbed) fever, Ignaz Semmelweis, a Hungarian obstetrician working in Vienna, made a landmark contribution to its prevention when he demonstrated that contaminated hands of medical attendants were spreading the disease and that this spread could be minimized with antiseptic hand cleansing. At about the same time, Lister applied principles of antisepsis to wound care in an effort to change surgery from a last resort procedure which usually caused septic death to a comparatively safe practice. In yet another part of Europe, Florence

Nightingale was instigating radical changes in the management of hospitals for soldiers wounded in the Crimean War, and later for Army hospitals in India. Improvements in sanitation, hygiene and nutrition resulted in striking reductions in mortality from contagious disease among the soldiers. Although they were contemporaries and each was concerned with the control of what later became known as infectious diseases, not one of these three leaders apparently made reference to the work of any other. These individuals shared much of the prevailing misunderstanding of contagion in common with their medical colleagues of the day. Nevertheless, their innovations still today represent the primary structure of infection control practice.

Antisepsis in Obstetrics

Puerperal fever (PF), which we now know to be an infection caused most frequently by the group A streptococcus, was a deadly scourge of lying-in women for centuries. Hippocrates viewed PF as a fatal, inevitable disease. Epidemics in hospitals as well as in the community were recorded throughout the 17th and 18th centuries and the disease at that time killed about two-thirds of women who died in childbirth.¹ In 1822, Campbell in Edinburgh commented that "there is no disease in history of physic of more fatal tendency." In reference to an outbreak of PF in Paris, 1750, we are told that not a single victim survived.² The disease was so prevalent and hospital outbreaks of such proportion that one physician of the times speculated that rates of PF in lying-in hospitals were being hidden or that deaths were recorded as being from other causes in an attempt to hide the problem.³ The disease was particularly devastating because it struck, unpredictably, healthy young women. PF took a greater toll among the poor and working

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class women who were more likely to give birth in hospitals than among the middle and upper class women who were attended at home. The literature abounds with descriptions of the clinical picture. The patient was:

"... seized with a rigor, or shivering fit, which was succeeded by a great degree of heat often terminating in profuse perspiration, and severe pain in the abdomen. The pain had no complete intermission... the pulse became rapid... the head was often affected by pain, but more commonly with giddiness and a sense of confusion... the skin was generally hot and dry; but sometimes it was moist, or covered with profuse perspiration... the melancholy scene was usually closed in a few days..."⁴

Autopsy findings in cases of PF were always similar, describing profound sepsis: "The omentum had lost about half its substance by suppuration... there was about half a pint of pus and extravasated serum in the cavity of the abdomen."² And, "a yellow fetid liquor mixed with pus, were found in the cavity of the abdomen and pelvis."⁵

The prevailing belief was that PF was caused by certain atmospheric conditions or miasmas such as cold weather and changes in the air, or by conditions resulting from the puerperal state itself: retention, overflow and stagnation of lochia; emotions; severe labor; rising too early after parturition.³ By the end of the 18th century, however, a few physicians suggested the contagious nature of PF and reduced rates by practicing general cleanliness and isolation of cases. In 1795, accounts of the transmission of PF by lying-in attendants stated,

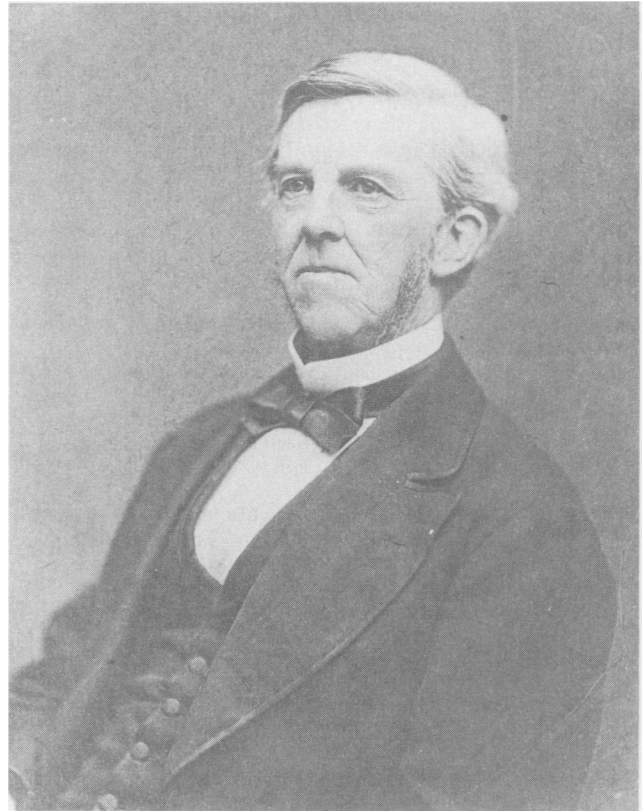
"That the cause of this disease was a specific contagion, or infection, I have unquestionable proof... the infection was as readily communicated as that of the small pox, or measles, and operated more speedily than any other infection. I plainly perceived the channel by which it was propagated... I could venture to foretell what women would be affected with the disease, upon hearing by what midwife they were to be delivered, or by what nurse they were to be attended."²

Even when contagion was considered as a possible cause of PF, it was usually in very general terms as something spread in the environment. In describing the cause of hospital epidemics in 1815, Hey said:

"All epidemics in this climate seem to be propagated by a contagious effluvium arising from the bodies of the sick, or other matters named fomites, which they have infected in the course of the disease."⁴

This vague idea of contagion is not surprising since the germ theory was not firmly established by Pasteur until several decades later, and there was a strong anticontagionist bias in early 19th century medicine.

As early as 1829 in a Dublin hospital, Dr. Charles White had markedly reduced the rates of PF by disinfecting wards with chlorine gas and chloride of lime.⁶ Even he, however, attributed PF in part to "bad fashions and customs" such as tight stays and bindings and sedentary life (White's "On Puerperal Fever" reprinted in ref. 6). Thus it was believed that PF was in the nature of things and, to a large extent, beyond the control of the medical profession. Treatment for PF, as for many diseases of the day, included purging and blood letting, but little attention was paid to prevention. To some extent, PF was attributed to women's behavior. The attitude that the disease could be prevented by personal behavior may have been one factor contributing to reluctance by the medical community to consider other causes.⁷



Dr. Oliver Wendell Holmes

One of the most convincing treatises on the infectiousness of PF was written in 1843 by an American physician, Dr. Oliver Wendell Holmes, who gathered evidence from a number of previously unpublished cases. For example, he reported that a physician in 1842, after attending a patient with erysipelas, lost five women to PF within the next 10 days. Another physician in the same year was infected through a cut in his hand during an autopsy of a man who died of gangrene. Over the next two months, all eight women he attended in childbirth developed PF. Two nurses who prepared the bodies of these women also developed sore throats and erysipelas, and one died. Such evidence was overwhelming, and Dr. Holmes presented his case in a lucid and eloquent manner. Unfortunately, this treatise was published in an obscure, short-lived medical journal with limited circulation.⁸

In 1852, two prominent obstetricians, Dr. Hodge from the University of Pennsylvania and Dr. Meigs from Jefferson Medical College, published articles arguing strongly against the contagious nature of PF.⁹ Hodge, the more polite of the two, gave several reasons why PF could not be infectious. He argued that it occurred primarily in hospitals and therefore probably resulted from irregularities such as anxiety and irritating bowel contents brought about by being in an unfamiliar environment. Additionally, since it occurred after rather than before delivery, labor must be part of the cause. He further contended that the infectious nature of erysipelas had not even been proven and that, "The negative cases so far outweigh the positive cases, that the latter must be regarded as exceptions."¹⁰ Most importantly, Dr. Hodge implied that the mere suggestion that PF might be transmitted by medical attendants was abhorrent, would damage the

trusting physician-patient relationship, and that fear engendered in the laboring woman by such a suggestion might, in itself, cause her to get the disease. "Cruel, very cruel, is it, therefore, to suggest such ideas to the parturient woman, at any time, even during the existence of epidemic diseases."¹⁰

Holmes in 1855 in a rebuttal to the objections of Drs. Hodge and Meigs, reprinted his essay of 1843 with an introduction discussing the strengths of the evidence.¹¹ The restraint and clarity of his logic make his opponents appear pompous by comparison. He refuted the argument of negative cases, for example, with an analogy:

"A man might say, 'I was in the Battle of Waterloo, and saw many men around me fall and die, and it was said that they were struck down by musket-balls; but I know better than that, for I was there all the time, and so were many of my friends, and we were never hit by any musket-balls. Musket-balls, therefore, could not have been the cause of the deaths we witnessed.'"¹²

Holmes clearly wanted to extricate himself from further conflict about this issue. In his rebuttal he concluded.

"I do not expect ever to return to this subject. There is a point of mental saturation, beyond which argument cannot be forced without breeding impatience, if not harsh feelings, towards those who refuse to be convinced. If I have so far manifested neither, it is well to stop here, and leave the rest to those younger friends who may have more stomach for the dregs of a stale argument."¹²

These same sentiments are expressed repeatedly by others who also argued for the contagiousness and preventability of PF and other nosocomial diseases throughout succeeding years.

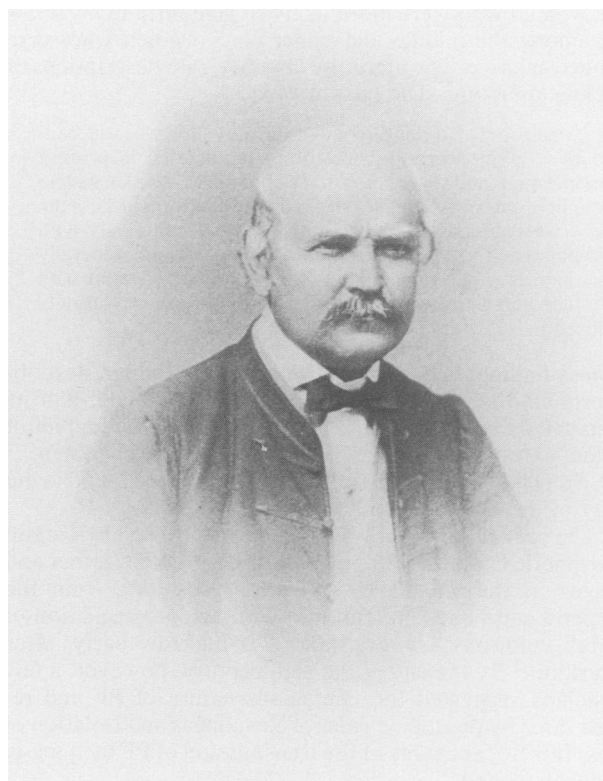
Although Dr. Holmes' work eventually received some recognition in the United States and Western Europe, there is little evidence that it had much impact on clinical practice, perhaps because the American medical community was still establishing its credibility. Indeed, it has been observed that "if Semmelweis could have written like Holmes, his *Aetiology* would have conquered Europe in twelve months."¹³

Meanwhile, evidence of the contagiousness of PF continued to accumulate. In 1846, a Scottish physician reported nine different clusters of cases in which PF was clearly spread between patients by medical attendants. This physician also recognized that, contrary to accepted ideas of the time, autopsies could shed little additional light on the causation of PF and could, indeed, be associated with its spread.

"Autopsies, I believe, can do little more in clearing away the difficulties which surround the consideration of the nature of PF, or in leading to a better means of cure . . . it seems well established that such examinations are extremely dangerous for the propagation of the disease."¹⁴

In 1849, Churchill in London summarized 106 known epidemics of PF which had occurred in the US and Europe between 1664 and 1846.¹⁵ His publications included discussion by a number of the most prominent physicians of the day. He postulated that the cause of PF was the pressure of the uterus on the intestines, and emphasized the need for fresh air, clean linen, and avoiding tight binding of the uterus and breasts.

During this same period, Ignaz Semmelweis, an Hungarian obstetrician, joined the staff of the Vienna Lying-in Hospital and noted a large discrepancy in death rates among women attended by midwives and midwifery students and those attended by physicians and medical students. Puerperal



Dr. Ignaz Semmelweis

sepsis was endemic and rampant in this hospital, and women were reputed to have their babies on the streets rather than risk the dangers of the hospital. Death rates among women attended by midwives were about 2–3 per cent and among those attended by medical staff, two to five times that rate. Semmelweis tested several hypotheses (e.g., variations in positioning of mothers during birthing and the larger hand size of male as compared to female examiners) to explain these differences, but to no avail. When one of his medical colleagues died of sepsis in 1846 after being inadvertently stuck with a sharp instrument being used for dissection of a woman who had died of PF, Semmelweis realized that whatever was causing PF was being transmitted by contact with autopsy material. He demonstrated that the discrepancy between the rates of PF among women attended by midwives and physicians was explained by the fact that only physicians performed post-mortem examinations. This discovery prompted Semmelweis to require all students and physicians to soak their hands in chlorinated lime after autopsies, before examining antepartal patients. Within a few months after enforcement of this practice, the PF deaths among women attended by medical staff had fallen to levels comparable to those of women attended by midwives.

Handwashing was certainly not a new practice in health care; physicians had been recommending general hygiene and cleanliness for decades. The unique contributions of Semmelweis were his recognition that the agent or cause of PF was being directly transmitted from one individual to another on the hands, and the concept of one necessary cause for the disease. He did not attribute the disease to some nebulous miasma, to foul air, or to a general effluvium, but a specific circumstance—that the hands became contaminated.

He was incorrect in thinking that the cause was only dead and decomposing matter, as he later discovered when PF was clearly propagated from a living patient with a uterine infection to the women in surrounding beds. Despite his incomplete understanding of the etiology of PF, Semmelweis appropriately intervened to prevent transmission of the disease. This was not the first time, nor would it be the last, that appropriate actions were taken to curtail infectious diseases for the wrong reasons or based on inadequate knowledge.

Despite his dramatic results and the fact that he carefully documented and verified his findings over the years, his discovery was not widely accepted among his medical peers. Animosity against Semmelweis was intensified by the fact that he was apparently a rather tactless, single-minded, perhaps pompous and fanatical personality. He was also a foreigner who spoke German very poorly. When invited to present his findings to the Vienna Medical Society, he initially refused, and did not even publish his results for 13 years.^{1,13,16} When he finally did summarize his work, the written product was quite polemical and communicated a resentful, angry tone. He felt that the "truth" of his work was so unquestionable that it should speak for itself. When, after more than a decade, little change in obstetrical practice had occurred, he finally published his only written work on the cause of PF, stating in the Preface, "I have given up hope that the importance of the truth of the matter would make all controversy unnecessary."¹⁷

By the 1880s, 40 years after the original observations of Semmelweis, there were a few practitioners who still referred to meteorologic influences on PF, or to the poisons of menstrual fluid and lochia,^{18,19} but these were the exception. The concept of the preventability of PF, and the importance of attendants' hands as a mode of spread appears in essentially every article about PF as does the need for hygienic hand cleansing. By 1856, the PF mortality rate in Pest, to which Semmelweis had returned, had dropped to 0.85 per cent and Tauszky attributed reductions in deaths from PF in Vienna from 8.9 per cent in 1834-48 to 1.3 per cent in 1863-78 to the continuing influence of Semmelweis.²⁰

Although some writers specifically credit Semmelweis for improvements in septic morbidity and mortality,^{20,23} there was a movement within the surgical specialty that had an even more profound effect on obstetrical practice than did Semmelweis himself. For the first time, terms such as antiseptic practices and antiseptics became common when referring to the prevention of PF. Indeed, most medical writers did not refer to Semmelweis, but rather to Lister as the founder of hygienic practices in obstetrics.²⁴⁻³¹

Antisepsis in Surgery

The status of the surgical specialty in the early nineteenth century was bleak. "Hospitalism", a term coined by Sir James Simpson to describe the array of serious infections which developed among hospitalized patients, was rampant.³² Hospital infections were so uncontrolled that several medical practitioners of the time proposed that epidemics could only be stopped by destroying hospital buildings and constructing them anew.^{33,34} Virtually every traumatic and surgical wound was accompanied by inflammation and suppuration. Pus is rare in wounds today and is always considered a serious sign of infection, but it was in those days so universal as to be considered essential for healing, and was referred to as "laudable."³⁵ The vast

majority of surgical wounds were accompanied by tetanus, streptococcal infection, gangrene, or septicemia, and septic death rates following surgery were 60-90 per cent.^{1,4,6}

It was in this setting during the 1850s that Joseph Lister began his surgical practice in Edinburgh. He was troubled from the beginning by the high mortality rates. Interestingly, he traveled in 1856 to Vienna where he met with former colleagues of Semmelweis, but there is no evidence that he knew about Semmelweis or his findings.³⁷ However, when Lister heard of Pasteur's work on putrefaction in 1865, he recognized the application of the germ theory to surgical practice. He believed that wound contamination emanated from the air. His application of dressings soaked in carbolic acid to surgical wounds had dramatic and marvelous effects. After some initial success, Lister undertook a series of human and animal studies and carefully documented and published his results within two years of his first discovery.⁸

Over the next 15 years, Lister continued his clinical investigations, frequently modifying his techniques (he was criticized for these frequent modifications) and published extensively in the major medical journals of the time. Because of his belief that air contamination caused wound putrefaction, Lister also insisted on the use of carbolic acid spray in the operating suite. This spray was quite toxic and caused some poisoning deaths.³⁹ In an address in Berlin in 1870, Lister himself acknowledged that use of the spray was an error.

It was difficult for some of Lister's contemporaries to realize the nature and value of surgical cleanliness. For one thing, Lister's methods were very complicated and there was confusion about frequent, minor changes in technique. Not all who used his methods were successful. Earle points out that in America "hospitalism" was less of a problem because hospitals were smaller and less crowded.⁴⁰ Additionally, the acceptance of antisepsis was contingent upon acceptance of the germ theory, which was difficult for many practical professionals. Hamilton makes a strong argument that improved host defenses and nutritional status were also important contributors during that time period to improved surgical mortality and infection rates.⁴¹

Nevertheless, most critics and historians of that time period agree that a significant advance was made:

"Notwithstanding the imperfections of the theory of Lord Lister, the scientific basis upon which it was founded had never been shaken. The fact that modern surgeons have discarded the paraphernalia originally designed does not in any manner overthrow the germ theory, but tends rather to establish it more firmly."³⁶

Before Lister, the importance of cleanliness in hospitals was recognized, but Lister's unique contribution was his application of the germ theory to surgery and his realization that everything contacting a wound should be rendered free of germs.

Perhaps as a result of Lister's prolific writing and speaking, because of his appointment in 1870 to the Chair of Clinical Surgery in Edinburgh, and because of the dramatic results he obtained and carefully documented, his methods of antiseptic surgery were acknowledged by the medical community within a few years. Terms such as "Listerism" along with statistics demonstrating dramatic reductions in infection and death^{39,42-45} began appearing throughout the world. There were dissidents, of course,⁴⁶ but between 1870 and 1890, antiseptic surgery became almost universal, and Lister's influence was widely recognized. Indeed, common



Dr. Joseph Lister



Nurse Florence Nightingale

thinking as reported by one medical historian in the 1920s was that Lister “transformed the methods of operative surgery, and they are by no means limited to mere wound treatment; they have led to extraordinary changes in surgeons, hospitals, and lying-in chambers.”⁴⁸

Antisepsis In Nursing

Contemporary with Lister, but in a different field of health care, Florence Nightingale was pioneering hygienic innovations among British soldiers at war. In 1854 at the age of 34 years she became the first female nurse sent by the British Army to provide care to soldiers sick and wounded in war. When she arrived with a group of carefully chosen nurses at the Scutari Hospital in the Crimea, conditions were deplorable, with vermin crawling, walls and floors wet with excreta, inadequate food, and little clothing or bedding for patients. Fortunately she was a meticulous record keeper and writer, recognizing the value of statistics for influencing health policy.⁴⁹ For that reason, we have excellent data available from Scutari, as well as from hospitals, public health agencies, schools, and other projects with which she was involved throughout her life. In February 1855, the death rate at Scutari was 42 per cent. By June of the same year, the militant discipline which Nightingale applied to initiate the sanitary and administrative changes resulted in a reduction in the death rate to 2 per cent.⁵⁰

After two years in the Crimea, Nightingale returned to London and continued her reform efforts from her chambers, where she stayed for the remaining 54 years of her long life. Her work resulted in sanitary reforms in the British military, workhouses for the poor, schools, and public health agencies as well as in hospitals. She wrote over 200 books and articles and more than 12,000 personal letters to this end.⁵¹ Despite the effectiveness of her sanitary reforms in improving public health and reducing death rates from infectious diseases, Nightingale, unlike Semmelweis and Lister, tenaciously held to the belief, shared by many of her medical colleagues, that diseases such as cholera, typhus, scarlet fever, and “hospitalism” were spread by a general state of filth, by an unhealthy and unclean environment.

It was said by a contemporary of Nightingale that “she has an utter disregard of contagion; I have known her to spend hours over men dying of cholera and fever.”⁵² She did indeed have a contempt for the concept of personal contagion. Even when she herself suffered a near-fatal case of Crimean fever after attending a sick soldier, she attributed this to her own tiredness. The idea of person-to-person transmission of disease was repugnant to her, as it did not fit into her concept of the ordered and controlled nature of the universe.⁵³ She lamented that “mystic rites” such as disinfection and antisepsis “take the place of sanitary measures and hygiene.”⁵⁴

These views are reflected in all of her writings. In “Notes on Hospitals” she attributed hospital sepsis to overcrowding the sick, deficiencies of fresh air and light, poor architectural design, and lack of cleanliness, while refuting contagion:

“... What does ‘contagion’ mean? It implies the communication of disease from person to person by *contact*. It pre-supposes the existence of certain germs like the sporules of fungi... There is no end to the absurdities connected with this doctrine.”⁵⁵

In “Notes on Nursing” she clearly delineated themes that pervaded her life’s work: “True nursing ignores infection, except to prevent it. Cleanliness and fresh air from open

windows, with unremitting attention to the patient, are the only defense a true nurse either asks or needs."⁵⁶ In this treatise she mentioned handwashing only once, and that in the context of general hygiene, "Every nurse ought to be careful to wash her hands very frequently during the day. If her face too, so much the better."⁵⁶

In a letter to Dr. Gillham Hewlett about a cholera outbreak in Bombay she complained that sanitary conditions in Europe were regressing because of the belief that cholera could be transmitted person-to-person. She maintained that cholera was due to pollution of air, buildings and water. She commented that "attendants do not catch the disease from the sick, any more than they do from poisoned cases."⁵³

Nightingale recounted an outbreak of PF which occurred in St. John's House where she was supervising a training school for midwives:

"A pregnant woman, who was under treatment for erysipelas in the hospital, was delivered in a general medical ward . . . A midwife was told off to attend her, who was not suffered to be near the midwifery wards for a considerable time. The erysipelas case died of puerperal fever; and this death was followed by a succession of puerperal deaths in the lying-in wards until November, when the wards were as soon as possible closed."⁵⁷

This school for midwives remained permanently closed, despite the fact that, even during the epidemic, the death rate was 3.5 per cent, a rate comparable to the 4-8 per cent rates of PF deaths throughout London.⁵⁸ Nightingale recognized that "the smallest transference of putrescing miasm from a locality where such miasm exists to the bedside of a lying-in patient is most dangerous,"⁵⁷ and her answer to the problem of puerperal sepsis was that, whenever possible, women should have their babies at home to avoid the unhealthy hospital environment. It should be noted that Nightingale's view of contagion was a prevalent one, shared by the majority of her medical contemporaries.

Even though Nightingale did not adopt the idea of personal contagion or recognize the importance of antiseptics in the way that Semmelweis and Lister did, her contributions to health care complemented theirs. While they were concerned with individual spread of disease and prevention of direct contamination of wounds and tissues, Nightingale was

concerned with a clean and healthy environment. It was absolutely clear from the results of her reforms that infectious diseases were being spread in the dirty and crowded environments of hospitals and military camps. And even though she did not believe in antiseptics, she insisted upon absolute cleanliness of the environment, the staff, and the patients.

Antisepsis Today

The three individuals discussed above each made unique contributions to hospital antisepsis and infection control. They can be compared in several ways (Table 1). Each was confronted in their individual practice settings with problems of infection of enormous magnitude, and each set about to reduce rates of "hospitalism". None initially knew about the germ theory. There are no records of whether Semmelweis ever did and, if so, what he thought about it. Lister soon applied it in clinical practice, but Nightingale adamantly denied its veracity. Each concentrated efforts on some aspects of hygiene and made lifelong commitments to making their innovations. They encountered serious resistance from peers and colleagues. Their varying degrees of success and recognition were dependent as much on personal attributes and resources as on the "truth" of their suggestions. Although each had an incomplete understanding of disease transmission, their innovations, taken together, have revolutionized health care. Semmelweis recognized the importance of person-to-person spread by direct contact and initiated strict antiseptic handwashing. Lister developed the techniques of antiseptic surgery and wound management. Nightingale emphasized the need for general environmental and personal cleanliness.

In health care settings today, all three of these elements have been incorporated into standards of practice, and since the turn of the century the problem of "hospitalism" or nosocomial infections has been dramatically reduced. Nevertheless, nosocomial infections continue to be one of the major preventable, iatrogenic complications of hospitalization, affecting at least 5 per cent of patients discharged from hospitals⁵⁹ and costing, in acute care facilities alone, more than \$4 billion annually in the United States.⁶⁰ Approximately one-third of these infections are preventable.⁶¹

TABLE 1—Contributions of Three Practitioners to the Development of Antiseptic Practice

	Semmelweis	Lister	Nightingale
Clinical Specialty	Obstetrics	Surgery	Nursing
Years of Active Professional Practice	1849-1860	1856-1889	1854-1900
Major Contribution	Hand antisepsis	Antiseptic surgery and wound treatment	Hospital sanitation, personal hygiene
Efforts to Disseminate Information	Refused offers to address medical colleagues; published only one major paper, 13 years after his findings	Published at least 50 papers in major medical journals; extensive speaking engagements	Refused speaking engagements; published about 200 books, pamphlets and articles; prolific personal correspondence (over 12,000 letters)
Personal Characteristics	Not well liked, volatile; was a 'foreigner' where he practiced; minimal personal or family influence	Well liked and respected; influential and financially comfortable family	Reclusive by nature; refused public appearances and recognition; influential and financially comfortable family; many supporters with political influence
Time from Innovation to General Acceptance	About 40 years	5-10 years	5-10 years

Within a few years of the inception of the antiseptic era, one could still hear laments over the fact that practitioners, even proponents of antiseptics, were not adhering to proper techniques.^{5,29} Almost 100 years ago, a prominent physician described

“... men who have trained nurses, sterilized dressings, and broiled instruments, but who, after they have washed for the operation, shake hands with a spectator, put a hand in a pocket, remove instruments from an old, blood-stained case, help carry a table, handle dusty bottles, or use a handkerchief yet they say they use every antiseptic practice... the great fact remains that the principles of cleanliness underlying both (asepsis and antiseptics), though adopted theoretically throughout the world, are really carried out most imperfectly.”²⁹

This problem continues in current practice. Handwashing, for example, has been shown in several observational studies to occur after less than 50 per cent of patient contacts in hospitals, even among patients on isolation precautions for recognized infections.⁶²⁻⁶⁵ The fact that surgical wound infection rates can be significantly reduced merely by reporting specific infection rates to the surgeons themselves is evidence that the individual practice of antiseptics and hygiene still has a measurable effect on patient risk of infection.⁶⁶ Studies in the decade of the 1980s continue to demonstrate significant reductions in infections by increasing handwashing.^{67,68}

Certainly a number of factors in addition to the practice of antiseptics also influence a patient's chances of acquiring a nosocomial infection. Most importantly is their underlying risk, which is influenced by the complex interaction of variables such as age, severity of illness, presence of chronic disease, and immune function. These factors are generally not amenable to preventive strategies in the acute care environment. Within the health care setting, the very therapies that are life saving (e.g., surgery, invasive diagnostic tests, and use of medical devices) unavoidably increase risk of infection. Additionally, a number of innovations in patient care practices related to antiseptics and hygiene have occurred in tandem, rarely as singular events. Hygienic handwashing, preoperative preparation of the patient's skin, gloving and sterile draping during surgery, isolation precautions, disinfection of instruments, autoclaving, and proper waste disposal are examples of the myriad practices which are all standard in modern medical institutions. At the same time, standards of living and public health in general have improved. Thus, for ethical and practical reasons, it is not possible to sort out the independent contribution of each preventive factor to the risk of infection.

So many decades have passed since hospitals have evolved from pest houses to centers for treatment and cure of disease that it is easy for health care personnel to lose sight of the fundamental importance of personal hygiene and antiseptics. The purpose of this historical summary is in part to serve as a reminder that the innovation of antiseptics was associated with significant reductions in septic mortality in a variety of settings. We cannot always pinpoint exactly which specific procedures are more or less effective; it is almost certainly a combination of many. Nevertheless, in light of historical and current evidence of efficacy and the evidence of continued inadequacies in practice, it seems reasonable to speculate that further reductions in nosocomial infection rates are possible by a more careful application among individual practitioners of the basic principles of antiseptics.

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